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The description of the facilities and processes included in this letter are based on my observations during my site visits and what I have learned during communications with these companies. I am attempting to portray the facts as I know them, about the operations, and am not interpreting those facts.

- A description of the furnaces

Bullseye and Uroboros both primarily use a furnace type called a "day tank." These day tanks resemble larger production furnaces used in the container and float glass industries, but are much smaller. They are built on-site and are composed of several different types of refractory (brick) material. The general design is a cube with a rounded (crown) top. It is filled with glass at the bottom and gas an air or oxygen fired just above the maximum glass line. The exhaust is then vented out of a flu. When the glass is finished melting, it must be removed with a ladle. Since often these furnaces are changing color, they remove as much glass as possible before starting the next batch. If they are making the same color, they may leave a little in the bottom between melts.

Bullseye also has a few pot furnaces which are made of a solid ceramic material that sits in a refractory lined construct which heats the pot from the sides. This is a small amount of the overall production. The remainder of this discussion focuses on the day-tanks/furnaces.

The day tanks at Bullseye are primarily fired using oxygen and natural gas. There are two burners in each day tank on opposing corners. The day tanks at Uroboros use air and natural gas and some have a heat exchange (recuperator) to pre-heat the combustion air. Most have one burner. The combustion happens above the raw materials/glass and heat transfer happens through the surface of the glass, where there is also volatilization of raw materials. Off gassing from this volatilization and offgassing from chemical reactions within the glass are exhausted out the stack with the combustion gases.

Temperatures in the furnace are generally around 2500 degrees F during melting. I understand the furnaces can be dialed back slightly while glass is ladled out if the glass doesn't harden too much. After the furnace is empty, they are turned back to high in order to pre-heat the furnace back up to 2500 before charging new raw materials.

- Production schedule

For the day tanks at Bullseye and Uroboros, they melt on an approximately 24 hour schedule with 5-8 hours to add raw materials (they break up the raw materials into smaller batches and "charge" the furnace several times over this period), 6-8 hours to cook, and 6-8 hours to ladle glass out of the furnace.

My understanding is that these furnaces are kept hot for at around 350-500 melts of glass (around 24 hours per melt). Then they are cooled to ambient temperature, completely dismantled, and all of the brick is replaced before it is reheated and put back in operation. Once the furnace begins operation after a re-bricking, the furnace is always kept above 2000 F and are constantly firing natural gas and air (or oxygen). These furnaces are never cooled to ambient temperatures if they are not being re-bricked. For the most part the furnaces melt batches of glass sequentially, with only a brief reheat period from the lower temperatures at the end of a batch (2200 F or so) back up near 2500 F. However, the furnaces can be idled down to 2000 F as well if they are not needed to melt glass.

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Each business may have a slightly different operating schedule. My understanding is that Bullseye melts glass from Sunday mid-day to Friday evening. Uroboros operates about 4 consecutive days per week (M-Th, or T-F). Furnaces can idle at other times (meaning sitting empty but at least 2000 F), because of holidays, economy, or desire to coordinate furnace schedules so their products can be mixed.

- A description of the overall process

At both facilities they mix their own recipes of glass, which contains basic ingredients like sand and smaller ingredients like metal oxides (for color and glass quality). They then mix these ingredients together and then add them to the furnace over a period of 5-8 hours. Once the glass is done cooking, workers hand ladle the glass out and roll it into flat sheets. These flat sheets are then coated (if necessary), and put through an annealing lehr to control the cooling so the glass doesn't fracture. The glass sheets are then trimmed and packed for shipping to customers (or sale in house). The trimmings can be re-melted in future batches or can be crushed to sell as a product called "frit."

- Anything else you think we should know about the glass manufacturing process

There is nothing else that I can think of right now. Please let me know if you have any other questions or if you would like more information about the process overview I included here.